Health Emergency and Disaster Nursing (2026) **13**, 91–105

ORIGINAL ARTICLE

Relationship between community attachment and disaster prevention awareness and health status among residents in disaster-affected areas

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Abstract

Aim: In this study, we aimed to investigate the relationship between disaster prevention and community awareness and physical and mental health among residents of the Yunohira district of Yufuin town, Oita Prefecture, Japan. We also aimed to examine the factors that help prevent an accelerated population decline after a disaster.

Methods: We conducted a questionnaire survey on residents of Yunohira district regarding their attributes, physical and mental health, disaster experience and prevention, and community awareness. We then performed statistical factor analysis on the collected data.

Results: The residents of the Yunohira area showed a high level of disaster awareness and strong attachment to their community. Although disasters appeared to have a lasting impact on their physical and mental health, those who had experienced a disaster actively engaged in self-care to overcome such challenges. Additionally, community attachment positively correlated with changes in health status, regardless of disaster experience. However, high disaster awareness and strong community attachment alone were found to be insufficient for implementing disaster preparedness actions.

Conclusions: The present findings suggest that strong community attachment may be associated with lower disaster-induced physical and mental fatigue. This attachment could be one of the reasons why the population decline did not accelerate even after repeated severe disasters. Furthermore, as the use of hazard maps, which are the initial step in disaster prevention actions, faces a number of obstacles, promoting the use of hazard maps that are easy for residents to use remains an urgent need.

Keywords: community attachment, community resilience, disaster experience, disaster prevention awareness, health survey

INTRODUCTION

Japan has a limited land area and steeply sloped rivers. In addition, due to the effects of climate change, "linear precipitation zones" and typhoons have become more likely to occur during the rainy season in recent years, causing extreme localized heavy rainfall across the country (Kawase et al., 2023). These geographical and weather conditions have led to an increase in the frequency and severity of disasters caused by heavy rainfall in Japan. In particular, disasters such as flooding and landslides due to heavy rain pose significant threats to the lives and physical and mental health of residents in mountainous regions. The Yunohira district of Yufuin town, Yufu city, Oita Prefecture, is located in a valley surrounded by mountains on all sides, with the Kagono

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Received 1 April 2025; accepted 11 February 2026

DOI https://doi.org/10.24298/hedn.2025-0010

River flowing along the valley formed by the eastern and western mountains. Hot spring resorts and settlements have developed on both sides of the river. However, the river basin in the Yunohira area is narrow and steep, making it prone to flooding during heavy rainfall. Additionally, because the Yunohira area is located within a valley, it faces a high risk of landslides, debris flows, and even land subsidence. The area has repeatedly experienced house collapses and flooding because of heavy rainfall in the past (Minami, 2023). After a heavy rainfall in July 2020, residents of the Yunohira area formed a voluntary disaster prevention organization. Since that time, they have been working to address challenges by conducting evacuation drills and holding discussion sessions. Through volunteer activities such as post-disaster recovery support in Yunohira, the present author began to wonder whether residents' awareness of disaster prevention and their community may be related to their health status, based on the region's unique characteristics and their positive attitude toward disasters. However, it is not yet fully understood how both disaster and community awareness affect the health of residents in disaster-affected areas. In fact, to our knowledge, no reports have specifically focused on the relationship between community attachment and the health of residents.

Currently, in mountainous regions of Japan, population decline is progressing as a result of factors such as low birth rates, aging populations, and population outflow (Atsumi & Ishizuka, 2023). In fact, in the 30-year period from 1995 to 2024, the population of Yunohira district decreased by more than half, from 544 to 229 (Yufu city, 2024). Generally, it is known that regions affected by disasters tend to experience accelerated population decline, and this trend is particularly pronounced in areas already facing depopulation (Atsumi, 2020; Ministry of Land, Infrastructure, Transport and Tourism, Urban Affairs Bureau, 2022). On the other hand, from 1995 to 2020, the average rate of population decline in the Yunohira area was −15.5% every 5 years, but from 2020 to 2024, the average rate was −1.7% over 4 years (Akiyoshi: Yufuin Regional Promotion Division, Yufuin Promotion Bureau, Yufu city, 2024, personal communication), which was lower than that for the entire Oita Prefecture during the same period (−3.44%) (Ranking data: Prefectures, Cities, Wards, Towns, and Villages, Population, Area and Population Density Rankings, 2024). During this time, heavy rains in the Yunohira district in July 2020 claimed the lives of four residents, and this was followed by the deaths of two workers near a river during a typhoon in 2022. Additionally, in 2023, landslides and other disasters occurred consecutively during heavy rains associated with a typhoon. However, in contrast to the period before 2020, the trend in population decline has clearly slowed down since then.

This poses the questions of why the population decline did not accelerate in the Yunohira district even after the occurrence of such disasters. With this question in mind, the present study aimed to investigate the relationship between disaster prevention and community awareness among residents, as well as their physical and mental health, following the heavy rains that occurred in July 2020. In addition, we comprehensively examined the relationship with community attachment and considered the factors that help prevent an accelerated population decline after a disaster.

METHODS

Participants

The participants were residents of all households in the Yunohira district of Yufuin town, Yufu city, Oita Prefecture. The exclusion criterion was age < 16 years. The total population of the Yunohira district as of April 1, 2024 was 229, of which, 60 individuals agreed to participate in the present survey. Additionally, responses from four individuals who spent most of their day working in the Yunohira district and had been involved with the community for many years were also considered valid. Therefore, the total number of participants in the present study was 64.

Survey methods

From July to August 2024, a questionnaire survey was conducted over a total of 5 days, with two investigators working as a pair to interview each participating resident individually. To accommodate older residents, the survey was conducted face-to-face, and the participants were also allowed to respond by pointing to the options on a printed questionnaire. Additionally, open-ended questions were included to gain a more detailed understanding of the residents' awareness and needs. Residents who were older adults with impaired vision or hearing and unable to participate in a face-to-face questionnaire survey were excluded. Before conducting the survey, permission was obtained from the Yufuin Town Promotion Bureau of Yufu city and the head of the Yunohira Neighborhood Association. Flyers detailing the purpose and content of the survey, as well as the schedule for home visits, were created and distributed to residents through a community notice board. Furthermore, a preliminary explanation of the survey was given at a disaster prevention seminar held on June 17, 2024.

Survey items

1) Attributes (six items)

The survey items included gender, age group, workplace location, years of residence, household composition, and disaster experience since the heavy rains in July 2020 (including those who evacuated). In the category of disaster experience since July 2020, those who selected "no experience of disaster" were categorized as "no disaster experience", whereas all others who selected any of the other options were categorized as "disaster experience". The participants were thus divided into two main groups.

The Yunohira district is a small community with a total population of approximately 200 residents. Since the heavy rainfall disaster in July 2020, disaster prevention and mitigation activities have become more active throughout the community. Considering the possibility that residents may have had close contact with disaster victims or may have been psychologically affected in some way, the following questions were asked regardless of whether the participants had experienced a disaster.

2) Physical health status (10 items)

(1) Regarding current health status, the survey included the following items: Health (H)-Q1: Current physical condition; and H-Q2: Whether individuals engage in activities for physical health.

(2) Regarding changes in health since the heavy rains in July 2020, the survey included the following items: H-Q3: Changes in physical condition up to the present; H-Q4: Changes in appetite; H-Q5: Changes in alcohol consumption; H-Q6: Changes in opportunities for physical activity; H-Q7: Changes in sedentary time; H-Q8: Changes in sleep duration; H-Q9: Changes in sleep quality; and H-Q10: Presence of any illness for which the resident has discontinued or interrupted treatment or medical visits. For these 10 items, H-Q1 and H-Q3 to H-Q9 were answered using a five-point scale, while H-Q2 and H-Q10 were answered using a binary choice ("Yes" or "No"). Additionally, for H-Q5, an extra option, "0: Do not drink alcohol at all", was included. For respondents who answered "Yes" to H-Q2, a follow-up question was asked to gather specific details about their health activities.

3) Mental health status (four items)

(1) The Post-Traumatic Stress Disorder (PTSD)-3-Item Short Screen (Itoh et al., 2017) was conducted to assess mental health (trauma) related to disasters and disaster experiences over the 30 days preceding the survey date using the following items: Mental (M)-Q1: I was distressed by unwanted thoughts or images related to the traumatic event; M-Q2: I had unpleasant dreams or nightmares about the traumatic event; and M-Q3: I experienced physical reactions (e.g., sweating, heart palpitations) when reminded of the traumatic event. Each response was given on a four-point scale (0: Never/only once, 1: Less than once a week/occasionally, 2: 2–4 times a week/about half the time, and 3: five or more times a week/almost always), with the total score ranging from 0 to 9. A previous study (Itoh et al., 2017) reported a sensitivity of 94.8% and a specificity of 86.1% for PTSD diagnosis using the threshold of a total score of 3 or higher, so in the present study, this same score was considered positive for PTSD suspicion. In accordance with this short screening, scores of 3 or higher were categorized as "suspected PTSD".

(2) M-Q4: Whether the resident engaged in activities for mental health was assessed using a binary choice item ("Yes" or "No"). Respondents who answered "Yes" were asked to provide more specific details through open-ended questions.

4) Disaster experience and disaster prevention awareness (nine items)

The survey included the following nine items: (Disaster) D-Q1: Changes in awareness of disasters since the heavy rains in July 2020; D-Q2: Changes in awareness of the risk of flooding and landslides; D-Q3: Checking disaster risk using a "flood hazard map"; D-Q4: Knowledge of the expected flood depth around the home; D-Q5: Checking disaster risk using a "landslide disaster warning map"; D-Q6: Sources of information on actions to protect life; D-Q7: Deciding what actions to take immediately to protect life in the event of a disaster; D-Q8: Participation in the disaster prevention seminar on June 17, 2024; and D-Q9: Utilization of the "House Rules Sheet" (Supplementary Fig. 1). The response formats were as follows. For all questions except D-Q6, the response format was a binary choice ("Yes" or "No"). For D-Q6, respondents were asked to select one option from the following four choices: Other, Forecasts, Warnings, and Conditions around the home. Additionally, for those who answered "Yes" to D-Q7, follow-up questions were asked to gather more specific details about their actions. The house rules sheet is a tool developed by the local government and distributed at the annual disaster prevention seminar. It is used by families to record emergency response plans—such as when to begin evacuation and where to evacuate—in the event of a disaster, and to review and share this information within the family.

5) Awareness of the community and neighborhood (six items)

The survey included the following six items: Community (C)-Q1: Attachment to the Yunohira area; C-Q2: Interaction with neighbors; C-Q3: Cooperation with neighbors during emergencies; C-Q4: Participation in community activities; C-Q5: Changes in neighborhood interactions since the heavy rains in July 2020; and C-Q6: Importance of community connections for physical and mental health. All six questions were answered using a five-point scale. For C-Q1, respondents who answered "very attached" or "attached" were categorized as having "strong attachment", whereas those who chose any other option were categorized as having "weak attachment". The participants were then divided into two groups based on the strength of their attachment to the community.

Degree of disaster prevention awareness (phase classification)

In implementing phased disaster prevention education for residents, Honma, Katada, and Kuwasaka (2008) evaluated the levels of disaster awareness using the CAUSE model proposed by Rowan (1994), which outlines the step-by-step goals of risk communication. They assessed the awareness levels in five phases: Phase 1: Never considered the existence of the risk; Phase 2: Became aware of the existence of the risk (Awareness); Phase 3: Gained a deep understanding of the risk (Understanding); Phase 4: Understood how to respond to the risk (Solution); and Phase 5: Took action to respond to the risk (Enactment). Honma et al. (2008) prepared five to seven questions for each stage corresponding to the levels of disaster awareness among residents, and then scored the level of understanding of disaster risks and evaluated the achievement status for each stage. Based on the results, they determined each resident's disaster awareness phase. By contrast, the present study aimed to reduce the burden on residents during the survey, so only one question was prepared for each stage. Specifically, D-Q2 was used for determining Phase 1, D-Q3 for Phase 2, D-Q4 for Phase 3, D-Q6 for Phase 4, and D-Q7 for Phase 5. For D-Q6, if respondents selected "conditions around the home", their evacuation responses were considered insufficient, and thus, they were not deemed to have reached the level required to move to the next stage. The achievement of each phase was assessed sequentially from lower to higher phases. If a resident did not fully achieve a particular phase, their disaster awareness phase was determined to be the previous lower phase. Therefore, even if they met the criteria for a higher phase, this was considered incomplete if the lower phases had not been fully achieved (Miyamura & Tanaka, 2016). Residents who cleared all the questions were classified as "proactive evacuees" who were capable of taking voluntary disaster prevention actions (Fig. 1) (Ministry of Land, Infrastructure, Transport and Tourism Kinki Regional Development Bureau, 2024).

Statistical analysis

In the questionnaire survey, the five-point Likert-type scale (ordinal scale) was treated as an interval scale and quantified, with the results presented as the mean ± standard deviation. Categorical data were expressed as percentages (%). Non-parametric analysis was used for statistical tests. The Wilcoxon rank-sum test was applied for numerical data comparisons between two groups, and Spearman's test analyzed correlations. The chi-square test or Fisher's exact test and residual analysis were used for categorical data comparisons. Multiple regression analysis, considering multicollinearity, was used to analyze factors influencing changes in health condition after the heavy rains in July 2020. For D-Q3 (confirmation of damage using a flood hazard map), factors associated with a "Yes" response were first analyzed using univariate logistic regression, followed by multiple logistic regression after selecting candidate variables. All statistical analyses were performed using JMP Pro (version 18.0.2 for Macintosh; SAS Institute Inc., Cary, NC, USA). P-values <0.05 (two-sided) were considered to indicate statistical significance.

Ethical considerations

The purpose and details of the survey were thoroughly explained to the participants both verbally and in writing. An overview of the explanation is as follows: 1) Respondents were assured that their answers would be anonymized using a coding system, and every effort would be made to protect their personal information; 2) The purpose, methodology, and expected outcomes of the research were clearly explained. It was emphasized that participation in the survey was entirely voluntary; 3) The survey participants' personal information—such as sex, age, area of residence, and household—was collected and used only to the extent necessary to achieve the purposes of the analysis and other intended uses. The primary purpose of the survey was for the author's graduation thesis, with no initial intention of external publication. However, if useful findings related to public health or disaster nursing were obtained, the results could be published at academic conferences or in scientific journals after obtaining approval from the Ethics Review Committee of the author's University Faculty of Medicine.

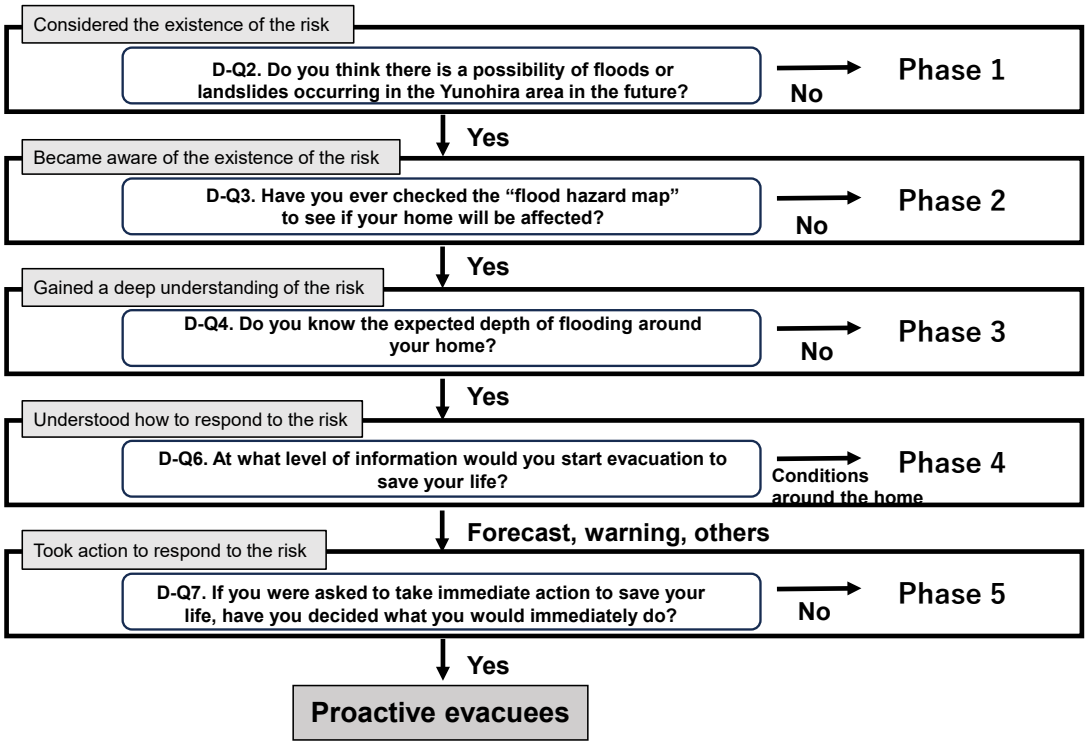

Figure 1 Flood disaster prevention awareness of Yunohira district residents (phase classification)
Concept of flood disaster prevention awareness levels and a flowchart of phase classification. In this survey, a single question corresponding to each stage of the residents' disaster prevention awareness levels was used, and the awareness level of each resident was determined based on their attainment of each stage. The questionnaire items were used for phase classification as follows: D-Q2 for Phase 1, D-Q3 for Phase 2, D-Q4 for Phase 3, D-Q6 for Phase 4, and D-Q7 for Phase 5. For question D-Q6, respondents who selected "conditions around the home" were considered insufficiently prepared for evacuation measures and therefore not deemed ready to progress to the next stage. Those who understood and successfully cleared all questions were classified as "proactive evacuees".

Additionally, the participants were informed that they could withdraw their consent to use their data even after agreeing to participate; and 4) This study was conducted as part of the "Oita Regional Collaboration Platform: FY2024 Fieldwork Support Project" in Oita Prefecture.

For those who agreed to participate, the survey was conducted after obtaining their signature on a consent form. To publish the results of the study as part of an academic paper, the research plan was prepared in accordance with the Declaration of Helsinki, and an opt-out application was submitted to the Ethics Committee of the author's University School of Medicine. After approval (Date of approval: February 27, 2025, Approval No.: 3063), the analysis was performed.

RESULTS

Background characteristics of the respondents (Table 1)

One older individual with impaired vision for whom the questionnaire survey was difficult to complete, was excluded. In total, 64 respondents (30 men [46.9%], 34 women [53.1%]) who had no problems in regard to cognitive function completed the questionnaire survey through face-to-face interviews, of whom, 84.4% were over 50 years old, 46.9% worked in the Yunohira area, and 34.4% were unemployed (Table 1). Additionally, 92.2% had lived in the area for more than 5 years, and the proportion of respondents with some disaster experience, including evacuation, was 76.6%.

Disaster experience and physical and mental health

Table 2 shows a quantitative comparison of physical health status based on disaster experience. No significant difference in "Current physical condition" was found between those with and without disaster experience. However, "Changes in physical condition up to the present" were significantly worse for those with compared with those without disaster experience ($P = 0.044$).

Table 1 Background characteristics of the participants (n = 64)

	n	%
Gender		
Male	30	46.9
Female	34	53.1
Age (years)		
10–19	0	0.0
20–29	2	3.1
30–39	1	1.6
40–49	7	10.9
50–59	14	21.9
60–69	16	25.0
70–79	13	20.3
≥ 80	11	17.2
Place of work		
Yunohira area	30	46.9
Yufu city other than the Yunohira area	10	15.6
Outside Yufu city	2	3.1
Unemployed	22	34.4
Length of residence		
Within 1 year	3	4.7
Within 2 years	1	1.6
Within 3 years	0	0.0
Within 4 years	1	1.6
> 4 years	59	92.2
Household members living together		
Single household	5	7.8
Married couple only	26	40.6
Married couple and unmarried children only	12	18.8
Single parents and unmarried children only	2	3.1
Three-generation household	8	12.5
Other	11	17.2
Details of disaster experience		
Heavy rains in July 2020	40	62.5
Typhoon No. 14 of 2022	37	57.8
Other disasters	20	31.3
No experience of disaster	15	23.4

In the category of disaster experience since July 2020, those who selected "no experience of disaster" were categorized as "no disaster experience", while all others who selected any of the other options were categorized as "disaster experience". Participants were thus divided into two main groups.

"Changes in appetite" and "Changes in opportunities for physical activity" also significantly decreased (P = 0.045 and P = 0.030, respectively), whereas "Changes in sedentary time" significantly increased (P = 0.023). The specific physical activities of those who answered that they engaged in activities for their health included "Doing radio calisthenics (i.e., a full-body exercise program widely used in Japan that consists of short exercises (approximately 3 minutes) performed in sync with music and announcements on the radio or television), Stretching, Playing ground golf (i.e., a simple golf game designed for older adults in Japan that can be played in parks), Taking walks, and so on". Additionally, no one had a PTSD score ≥ 4, but four respondents, all of whom had disaster experience, showed suspected PTSD (total score = 3) (Fig. 2). The specific practices mentioned by those who answered that they engaged in activities for their mental health included "Venting anger, Thinking only about success, and Saying silly things to laugh", among others.

Disaster prevention awareness (phase classification)

The percentage of respondents who answered that "There is a possibility of future floods or landslides in the Yunohira area" was significantly higher in the group with disaster experience (98%) than in the group without disaster experience (80%) (P = 0.037) (Table 3). Additionally, the percentage of respondents who answered that they "know the expected inundation depth around their home" was significantly lower in the group with disaster experience (30.6%) than in the group without disaster experience (66.7%) (P = 0.042). Among those who answered that they had decided actions to take when an evacuation order was issued, some responded that they would not move because evacuating would be more dangerous, whereas others said they would observe the situation before deciding whether to evacuate.

Fig. 3 shows the distribution of disaster prevention awareness among Yunohira residents, which was created based on the flowchart in Fig. 1. Phase 3 accounted for the largest proportion, at 37.5% (24 of 64 respondents), while proactive evacuees comprised 18.8% (12 of 64).

Local interactions and community awareness (Supplementary Table 1)

In total, 64.1% of the respondents had a strong attachment to the Yunohira area. Regarding "Interaction with neighbors", 75.1% chose either "Closely interacting" or "Participating in community duties". For "Cooperation with neighbors in emergencies", 71.9% selected either "Closely cooperating" or "Cooperating". However, only 36.0% actively participated in community activities. Regarding "Changes in neighborhood interactions since the heavy rains in July 2020", 75.0% responded with "No change".

"Attachment to the Yunohira area", "Interaction with neighbors", and "Cooperation with neighbors in emergencies" all showed significant positive correlations with

Table 2 Outcome of questionnaire on physical condition between participants with and without disaster experience

Specific questions asked in the survey	Disaster experience		
	Yes (n = 49)	No (n = 15)	*P*-value
We would like to ask you about your physical health			
H-Q1, What is your current health condition?	3.20 ± 0.71	3.40 ± 0.99	0.576
H-Q2, Is there anything you do to stay physically healthy?	53.1%	26.7%	0.086
Please tell us about any changes in your physical condition since the heavy rains in July 2020.			
H-Q3, How has your condition changed so far?	2.86 ± 0.35	3.13 ± 0.52	**0.044**
H-Q4, Has your appetite changed?	2.92 ± 0.28	3.13 ± 0.52	**0.045**
H-Q5, Has your drinking habit changed?	1.78 ± 1.42	1.20 ± 1.42	0.197
H-Q6, Have your opportunities for physical activity changed?	2.73 ± 0.57	3.07 ± 0.70	**0.030**
H-Q7, Has your sitting time changed?	3.14 ± 0.61	2.80 ± 0.41	**0.023**
H-Q8, Has your sleep schedule changed?	2.84 ± 0.47	2.87 ± 0.64	0.616
H-Q9, Has your sleep quality changed?	2.88 ± 0.60	2.80 ± 0.68	0.565
H-Q10, Do you have any illnesses for which you have discontinued treatment or medical consultations? (or have you ever stopped receiving treatment?)	2.0%	6.7%	0.417

Data are expressed as mean ± standard deviation or (%). Statistically significant data are shown in bold. For these 10 items, H-Q1 and H-Q3 to H-Q9 were answered using a five-point scale, while H-Q2 and H-Q10 were answered using a binary choice ("Yes" or "No"). Additionally, for H-Q5, an extra option, "0: Do not drink alcohol at all", was included. The specific options for the five-point scale are as follows: H-Q1 (1: Bad, 2: Not so good, 3: Normal, 4: Fairly good, 5: Good), H-Q3 and H-Q9 (1: Much worse; 2: Worse; 3: No change; 4: Better; 5: Much better), the five items of H-Q4, H-Q5, H-Q6, H-Q7, and H-Q8 (1: Much less; 2: Less; 3: No change; 4: More; 5: Much more).

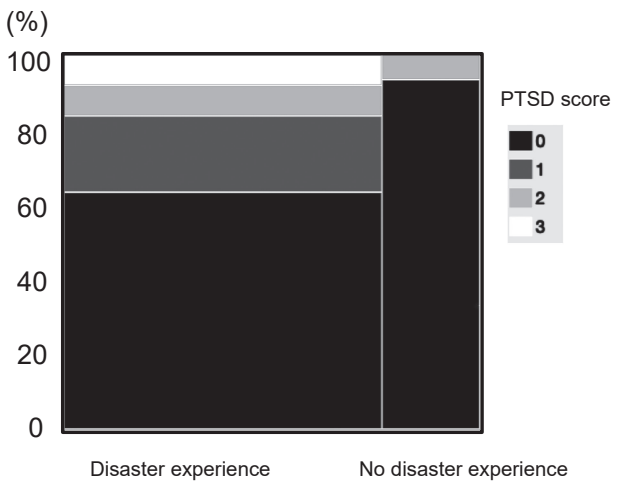

Figure 2 Comparison of PTSD simple screening tests between participants with and without disaster experience
The figure shows the percentage of participants who achieved the total scores for each item on the PTSD Simple Screen developed by Itoh et al. The minimum score is 0, and the maximum score is 9. The higher the total score, the higher the possibility of having PTSD. Individuals with a total score of 3 or higher are suspected of having PTSD. Black, dark gray, light gray, and white squares indicate respondents with total scores of 0, 1, 2, and 3, respectively. No one had a PTSD score ≥ 4.

each aspect of community awareness (Table 4). Notably, "Attachment to the area" and "Neighborly interactions" showed relatively strong moderate correlations with "Cooperation with neighbors in emergencies". Additionally, "Attachment to the area" and "Cooperation with neighbors in emergencies" showed strong moderate correlations with "Importance of community connections for physical and mental health" (Spearman's $\rho \geq 0.6$). In addition, five people in the strong attachment group responded that they had significantly increased their interactions after the disaster. On the other hand, three people in the weak attachment group responded that they had lost interactions after the disaster (Fig. 4). Although a chi-square test did not reveal a statistically significant difference ($P = 0.076$), residual analysis revealed that in the strong attachment group, the proportion of those who answered "much more contact" was significantly higher, whereas in the weak attachment group, the proportion of those who answered "no more contact" was significantly higher ($P < 0.05$).

Analysis of factors affecting health changes after the heavy rains in July 2020

Because the group with disaster experience was more aware of health deterioration after the heavy rainfall of July 2020 (Table 2), influencing factors were analyzed by not only the presence or absence of disaster experience, but also gender, age, level of flood disaster prevention awareness, and strength of attachment to the community (Table 5). Changes in health since the 2020 disaster showed a significant negative correlation with disaster

Table 3 Comparison of disaster prevention awareness between participants with and without disaster experience

Specific questions asked in the survey	Disaster experience		
	Yes (n = 49)	No (n = 15)	*P*-value
We would like to ask about your experience of disasters and your awareness of disaster prevention.			
D-Q1, Has your awareness of disasters changed since the heavy rains in July 2020?	89.8%	86.7%	0.662
D-Q2, Do you think there is a possibility of floods or landslides occurring in the Yunohira area in the future?	98.0%	80.0%	**0.037**
D-Q3, Have you ever checked the "flood hazard map" to see if your home will be affected?	71.4%	46.7%	0.119
D-Q4, Do you know the expected depth of flooding around your home?	30.6%	66.7%	**0.042**
D-Q5, Have you ever checked the "Landslide disaster information evacuation map" to see if your home will be affected?	77.6%	60.0%	0.197
D-Q6, At what level of information would you start evacuation to save your life?	-	-	
D-Q7, If you are asked to take immediate action to save your life, have you decided what you will do immediately?	71.4%	80.0%	0.740
D-Q8, Did you participate in the disaster prevention seminar on June 17, 2024?	20.4%	20.0%	1.000
D-Q9, Do you use our house rules sheet?	20.4%	26.7%	0.723

Data are expressed as (%). Statistically significant data are shown in bold. The eight items other than D-Q5 were answered using a binary choice ("Yes" or "No") and D-Q6 was asked to choose one of four options: 1: Other; 2: Forecast; 3: Warning; 4: Conditions around the home. One individual did not respond to D-Q4.

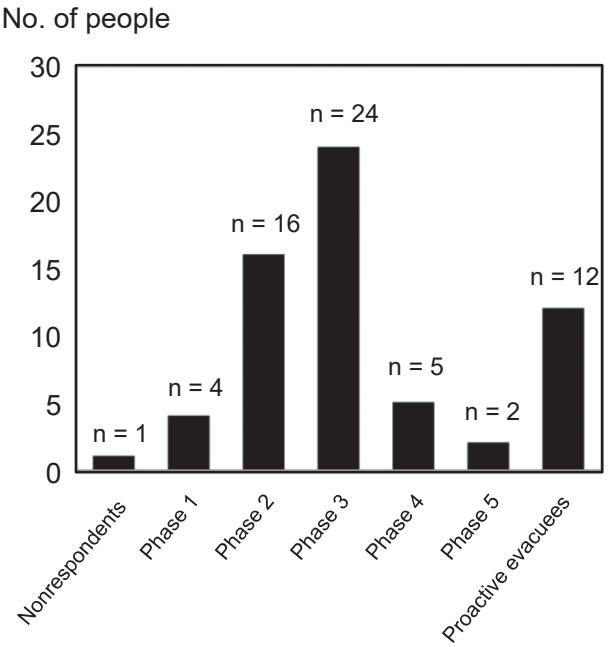

Figure 3 Disaster prevention awareness structure of Yunohira district residents by phase classification
The numbers above each bar graph indicate the number of residents who reached the indicated level. One person did not respond to D-Q4.

experience (correlation coefficient $\rho = -0.256$, P = 0.041) and a significant positive correlation with community attachment ($\rho = 0.288$, P = 0.021). Additionally, the results of multiple regression analysis, including gender and age, revealed that community attachment was independently and positively correlated with health changes since the disaster, regardless of gender, age, or disaster experience (standardized regression coefficient $\beta = 0.414$, P = 0.001).

Examination of factors to confirm damage to homes using a flood hazard map

To identify factors influencing the completion of Phase 2, which initiates disaster prevention actions (Fig. 1), we analyzed the following variables related to responses of "Yes" to D-Q3: "Have you ever checked the flood hazard map to see if your home will be affected?": gender, age, disaster experience, perception of future disaster risks in the Yunohira area (corresponding to the D-Q2, Phase 1 determinant), attending the disaster prevention seminar on June 17, 2024, utilization of the house rules sheet for disaster prevention (Supplementary Fig. 1), and level of community attachment (Table 6). The utilization of the house rules sheet for disaster prevention was identified as a significant influencing factor for confirming flood risk on the hazard map, with an odds ratio (OR) of 9.4 (P = 0.008). Next, from the significant items (P < 0.1), we selected three variables: "Disaster experience, Attending the disaster prevention seminar, and Utilization of the house rules sheet" along with gender and age group, making a total of five candidate variables. A multiple logistic regression analysis was conducted, and disaster experience and utilization of the house rules sheet remained as independent influencing factors, with ORs of 4.0 (P = 0.043) and 11.4 (P = 0.042), respectively.

Table 4 Correlation between the questionnaire scores on interactions with neighbors and community awareness

Specific questions asked in the survey **We would like to ask you about your interactions with the local community and your thoughts about the community.**	C-Q1	C-Q2	C-Q3	C-Q4	C-Q5	C-Q6
C-Q1, Do you have any attachment to the Yunohira area?	1.000					
C-Q2, How is your neighborhood interaction?	**0.442****	1.000				
C-Q3, Can you cooperate with your neighbors in an emergency?	**0.608****	**0.606****	1.000			
C-Q4, Do you participate in local activities?	**0.289***	**0.442****	**0.345***	1.000		
C-Q5, Have your relationships with your neighbors changed since the heavy rains in July 2020?	**0.321***	**0.395****	**0.291***	0.197	1.000	
C-Q6, Do you think community connections are important for mental and physical health?	**0.608****	**0.402****	**0.620****	**0.329***	0.238	1.000

The data show the Spearman correlation coefficient ρ. Statistically significant data are shown in bold; *P < 0.05, **P < 0.005. For the above six items, responses were asked on a five-point scale as follows: C-Q1 (1: No attachment at all, 2: No attachment, 3: Some attachment, 4: Attached, 5: Very attached), C-Q2 (1: No contact at all, 2: Almost no contact, 3: Just greetings, 4: Participate in routine activities such as cleaning the neighborhood, 5: Have close contact such as going back and forth between houses), C-Q3 (1: Do not think we can cooperate at all, 2: Do not think we can cooperate very much, 3: Probably cooperate, 4: Think we can cooperate, 5: Think we can cooperate closely), C-Q4 (1: Never participated at all, 2: Rarely participated, 3: Occasionally participated, 4: Often participated, 5: Actively participated), C-Q5 (1: No more contact, 2: Less contact, 3: No change, 4: More contact, 5: Much more contact), and C-Q6 (1: Not at all, 2: Not really, 3: Probably, 4: Somewhat, 5: Strongly). One individual did not answer questions C-Q3, C-Q4, and C-Q5.

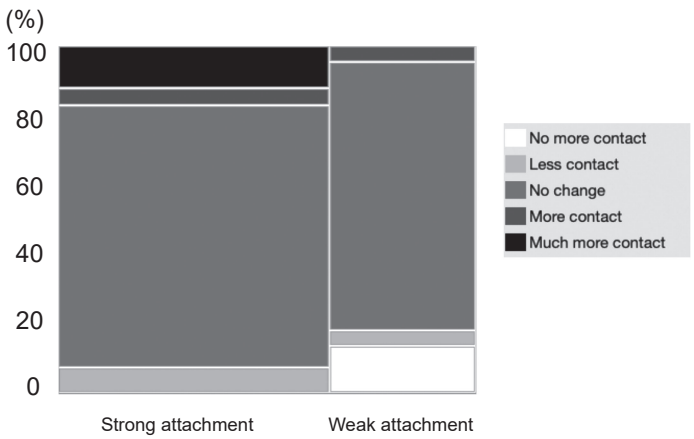

Figure 4 Comparison of changes in neighborhood interactions since the heavy rains in July 2020 between participants with strong and weak attachment
The figure shows the percentage of participants who had changes in neighborhood interactions since the heavy rains in July 2020 between those with strong and weak attachment to their community. For C-Q1, respondents who answered "very attached" or "attached" were categorized as having "strong attachment", whereas those who chose any other option were categorized as having "weak attachment". The participants were then divided into two groups based on the strength of their attachment to the community. Black is "Much more contact", dark gray is "More contact", medium gray is "No change", light gray is "Less contact", and white is "No more contact".

DISCUSSION

Changes in the physical and mental health of Yunohira area residents after the heavy rains in July 2020

Our survey, which was conducted 4 years after a disaster, found that those who had experienced a disaster were more aware of their health deterioration compared with those who had not (Table 2). They also reported decreases in physical activity and appetite. Additionally, all individuals suspected of having PTSD had experienced a disaster (Fig. 2). A factor analysis of health changes from the heavy rainfall of July 2020 to the present confirmed that these changes were not influenced by gender or age, but rather, disaster experience (Table 5). On the other hand, no significant difference in current health status was observed between those with and without disaster experience (Table 2). Furthermore,

Table 5 Simple correlation and multiple regression analyses on changes in physical condition since the heavy rains in July 2020

	Spearman correlation		Multiple regression	
Variables	ρ	*P*-value	β	*P*-value
Gender	−0.022	0.862	0.013	0.910
Age	−0.099	0.436	−0.149	0.194
Disaster experience	−0.256	**0.041**	−0.375	**0.002**
Degree of flood disaster prevention awareness (phase classification)	0.112	0.384		
Strength of attachment to the Yunohira area	0.288	**0.021**	0.414	**0.001**

The relationships between changes in physical condition since the heavy rains in July 2020 and disaster experience as well as other factors were examined by Spearman correlation and multiple regression analyses. Statistically significant data are shown in bold. Gender was defined as female (= 0) or male (= 1), age groups were quantified as follows: 10–19 years old is 1, 20–29 years old is 2, 30–39 years old is 3, 40–49 years old is 4, 50–59 years old is 5, 60–69 years old is 6, 70–79 years old is 7, and ≥ 80 years old is 8. Disaster experience was defined as "No" (= 0) or "Yes" (= 1), the level of awareness of flood disaster prevention (phase classification) was quantified as 1 for Phase 1, 2 for Phase 2, 3 for Phase 3, 4 for Phase 4, 5 for Phase 5, and 6 for those who were proactive evacuees. The five-point ordinal scale asking about "attachment to the Yunohira area" was treated as a numerical value, and the above five factors were used as candidate explanatory variables.

Table 6 Logistic regression analysis of factors associated with confirming home damage using flood hazard maps

	Univariate logistic regression			Multiple logistic regression		
Variables	Odds ratio	95%CI	*P*-value	Odds ratio	95%CI	*P*-value
Gender	1.091	0.388–3.071	0.869	1.184	0.366–3.835	0.778
Age	0.753	0.516–1.100	0.129	0.754	0.502–1.132	0.157
Disaster experience	2.857	0.870–9.380	0.083	3.994	1.005–15.874	**0.043**
Perception of future disaster risks in the Yunohira area	6.474	0.631–66.378	0.086			
Attending the disaster prevention seminar on June 17, 2024	3.548	0.710–17.718	0.089	0.963	0.105–8.842	0.974
Utilization of house rules sheet for disaster prevention	9.414	1.414–77.652	**0.008**	11.403	0.756–172.080	**0.042**
Attachment to the Yunohira area	1.054	0.636–1.746	0.840			

The factors of answering "Yes" to "D-Q3: Have you ever checked the flood hazard map to see if your home will be affected?" were explored by logistic regression analysis. CI, confidence interval. Statistically significant data are shown in bold. Gender was defined as female (= 0) or male (= 1), age groups were quantified as follows: 10–19 years old is 1, 20–29 years old is 2, 30–39 years old is 3, 40–49 years old is 4, 50–59 years old is 5, 60–69 years old is 6, 70–79 years old is 7, and ≥ 80 years old is 8. Disaster experience was defined as "No" (= 0) or "Yes" (= 1), attending the disaster prevention seminar on June 17, 2024, was defined as "No participation" (= 0) or "Participation" (= 1), and utilization of the house rules sheet for disaster prevention was defined as "No use" (= 0) or "Use" (= 1). The five-point ordinal scale asking about "perception of future disaster risks in the Yunohira area" and "attachment to the Yunohira area" was treated as a numerical value, and the above seven factors were used as candidate explanatory variables.

53.1% of those with disaster experience reported engaging in activities for physical health, which was about twice the rate of those without, and they were found to be activity engaged in a variety of physical activities. Similarly, 40.8% of those with disaster experience reported doing something for mental health (disaster experience vs. no experience: 40.8% vs. 26.7%, P = 0.377), and they seemed to make an effort to think positively. These findings suggest that although disaster experience continues to affect physical and mental health, those with disaster experience are practicing self-care and maintaining a positive attitude toward their health. In this study, 10.9% of the respondents reported that their "current" health condition was "not so good" or "bad". By contrast, a survey conducted 1 year after the disaster in an area where 91% of residents experienced partial or total destruction or flooding of their homes (8226 respondents) reported a rate of 25.2% (Hiroshima Prefecture Official Website, 2020). Additionally, a survey targeting 284 residents living in temporary or public housing conducted 3 years after a disaster reported a rate of 22.2% (Hitoyoshi city, 2024), both of which were more than twice the rate found in the present study. Health conditions are inherently influenced by the severity of the disaster and the time elapsed since the event. If the survey had been conducted shortly after the disaster, the results might have shown worse health conditions than the present data.

Disaster prevention awareness of Yunohira area residents

Several reports have utilized the phase classification

developed by Honma et al. (2008) to illustrate engagement in disaster prevention activities. In a survey of 500 residents across five cities in the Inagawa River basin, which includes areas with a high flood risk, the proportion of Phase 1 respondents was 64% (Ministry of Land, Infrastructure, Transport and Tourism Kinki Regional Development Bureau, 2017). Similarly, in Fujiidera city, Osaka Prefecture, located in the Yamato River basin, a longitudinal online survey targeting 1200 residents reported that the proportion of Phase 1 respondents decreased gradually, from 48.2% in 2018 to 48.1% in 2020, 47.0% in 2021, and 36.0% in 2022. This year-on-year decline in Phase 1 suggests that an increasing number of residents are becoming more aware of disaster risks, which also suggests a certain level of effectiveness in disaster prevention efforts (Itoh, 2024; Ministry of Land, Infrastructure, Transport and Tourism Kinki Regional Development Bureau, 2024). These previous two reports were not limited to disaster victims, so the initial awareness of disaster risks among residents may have been low. By contrast, a survey on disaster prevention awareness conducted 3 years after the Great East Japan Earthquake targeting tsunami survivors (248 respondents, 52% response rate) reported that the proportion of Phase 1 respondents was 23.0% (Miyamura & Tanaka, 2016). In comparison, the proportion of Phase 1 respondents in the Yunohira area was 6.3%, which is clearly lower than those in any of the previous reports. Additionally, the proportion of proactive evacuees was higher than the same proportions in other searchable areas (five cities in the Inagawa River basin and Fujiidera city) (Fig. 3). These findings suggest that a higher percentage of residents in the Yunohira area may have heightened awareness of the potential risk of flooding compared with other regions. However, unfortunately, it cannot be denied that the people affected in the Yunohira area may have originally had a low awareness of disaster prevention (Table 3). This is necessary to reconsider considering factors such as the characteristics of the residential areas of people with disaster experience (such as their distance from rivers) and their age.

Relationship between community attachment and disaster prevention awareness and health status among residents in the Yunohira area

Sekine and colleagues (2023) surveyed attachment to the community in six rural cities using a five-point scale. They found that the proportion of people who chose "very attached" or "attached" ranged from 33.5% to 48.3%. Similarly, another study that used a four-point scale reported that 44.8% of respondents felt attached to their community (Saijo City Official Website, 2019). By contrast, a survey conducted in seven urban areas, including Tokyo, Sendai, and Kobe, asked residents if they wanted to continue living in their current neighborhood (Ministry of Internal Affairs and Communications: Study Group on the Future of Communities in Urban Areas, 2014). If we interpret those who answered "yes" as having attachment to their community, the highest proportion recorded was 59.3%. However, in the Yunohira area, this proportion was 64.1% (Supplemental Table 1). These findings indicate that residents of the Yunohira area have a stronger attachment to their community compared with those in other rural cities, as well as in Tokyo and other cities with populations exceeding one million. An analysis of the relationship between community attachment and changes in neighborhood interactions since the heavy rains in July 2020 revealed that five people in the strong attachment group reported a significant increase in interactions after the disaster, whereas three people in the weak attachment group reported a loss of connection (Fig. 4). This finding suggests that strong community attachment is closely related to "mutual assistance" within the local community. Indeed, in the present study, community attachment showed a significant positive correlation with neighborhood interactions, cooperative relationships in emergencies, and participation in community activities (Table 4). Moreover, those with strong community attachment and proactive cooperation with neighbors strongly recognized that community connections are important for physical and mental health. Additionally, community attachment showed a positive correlation with health changes from the disaster to the present, independent of gender, age, or disaster experience (Table 5). These findings suggests that stronger community attachment is associated with lower levels of physical and mental fatigue reported after disasters.

Community resilience in the Yunohira district

Recently, the concept of "community resilience" has been attracting attention in the field of disaster studies. Sato, Matsunaga, and Taguchi (2022) define community resilience as "the capacity of a community to regain stability after a disaster, and the process by which community members act together in response to a disaster and utilize these actions to achieve stability after a disaster". They conducted a conceptual analysis of community resilience in disaster-related health care and identified three categories: "residents' health", "community development", and "enhancement of human connections". As described above, residents with strong attach-

ment to their community reported lower levels of disaster-induced physical and mental fatigue, and some stated that their social interactions actually increased after the disaster (Table 5 and Fig. 4). Furthermore, community attachment showed a significant positive correlation with neighborhood interactions, cooperative relationships in emergencies, and participation in community activities (Table 4). These findings suggest that "attachment to the community" is a factor that promotes community resilience.

Considering that from 1926 (Shōwa 1) to 2020, the only recorded loss of life due to natural disasters was one person in 2005, the six disaster-related fatalities after the heavy rainfall of 2020 are significantly high. Nevertheless, the population decline in the Yunohira area has not accelerated. Based on the present findings, we speculate that one of the reasons for this is the strong attachment of residents to the Yunohira area. Community attachment is considered to be one form of cognitive social capital (Sato et al., 2020). Ishimori (2004) reported that people with strong community attachment are more likely to want to continue living there and actively participate in local interactions, which strongly supports the findings of the present study. Factors that prevented the acceleration of population decline included a high level of disaster prevention awareness among residents of Yunohira district (Fig. 3) and their proactive efforts in reconstruction activities. Regarding the 2011 Great East Japan Earthquake, many affected areas continued to experience population decline for several years after the disaster (Reconstruction Agency Official Website, 2020). In this way, experiencing a disaster tends to accelerate population outflow. On the other hand, since the heavy rain disaster in 2020, the Yunohira district has been actively engaged in disaster prevention and mitigation as a community, including holding disaster prevention seminars and evacuation drills and establishing a voluntary disaster prevention organization. Such community initiatives are considered to be one of the reasons why disaster prevention awareness in the Yunohira area is relatively high compared with other areas. At the same time, we believe that the community's capacity to respond and adapt (equivalent to community resilience) is also a highly important factor in curbing population decline in the area. Considering that attachment to the community showed a significant correlation with active interactions with neighboring residents and participation in community activities (Table 4), it can be inferred that attachment to the community also forms the foundation of a community's response and adaptation capacities. Another factor may be the value of the region as a tourism resource. The Yunohira area is a historic hot spring area that dates back to the Kamakura period and is known as the second most popular resort hot spring in Yufu city, after Yufuin Onsen. Because it is possible to work from home, some people who visit as tourists fall in love with the area and later decide to move there. In other words, its value as a tourist resource supports population inflow. Thus, there are several possible reasons why the population decline in the Yunohira area did not accelerate after the heavy rains of July 2020. However, the fundamental basis appears to be each resident's attachment to the community and the community resilience formed on that foundation.

In 2017, Akita Prefecture, where the population decline rate has been particularly notable in recent years, conducted a fact-finding survey. In that report, Toyoda (2017), the surveyor, stated the following: "In communities within a declining population society, what is required is not community sustainability, but rather a resilient community that can flexibly transform itself". In the future, we plan to conduct a questionnaire survey to evaluate community resilience and reexamine its relationship with the demographics of the Yunohira area.

Future disaster prevention and mitigation issues in the Yunohira area

In this study, attachment to the community was found to be associated with the health status and disaster prevention awareness of residents. Therefore, it may be a key factor in preventing an accelerated population decline in the Yunohira area. Consequently, does strong attachment promote disaster awareness and prevention actions? Numerous reports have found that disaster awareness is significantly influenced by disaster experiences (Matsukiyo, 2012; Hamamoto, Shiraishi, Yasui, Iwamoto, & Shimada, 2017), and this was also observed in the present study. Additionally, some studies have reported that community attachment is related to disaster awareness (Matsukiyo, 2012; Hamamoto et al., 2017). However, when it comes to actual disaster prevention actions, only the characteristics of the disaster and past disaster experiences remain as influential factors, and it seems that strong community attachment alone is not sufficient to lead to practical disaster prevention actions (Matsukiyo, 2012). The level of disaster awareness for flood risks in the Yunohira area revealed that the proportion of Phase 1 was low, whereas the proportions of Phases 2 and 3 were high (Fig. 3). This indicates that although there is awareness of disaster prevention, significant barriers remain to translating this awareness into action. Then, among those who answered that they

had predetermined specific actions to take when an evacuation order was issued, three responses indicated hesitation to evacuate because it would be more dangerous. Furthermore, none of the respondents indicated that they would check the hazard map (data not shown). Regarding the initial step of disaster prevention actions—the utilization of flood hazard maps—community attachment did not remain as an influencing factor. Additionally, the perception of future disaster risks in the Yunohira area was not a significant factor. This suggests that the mere awareness of disaster risks is insufficient to prompt disaster prevention actions (i.e., even if Phase 1 is overcome, it does not necessarily lead to Phase 2). On the other hand, the utilization of the house rules sheet for disaster prevention remained a highly influential factor, independent of disaster experience, even in the multiple logistic regression analysis (Table 6). The following reasons may explain why the house rules sheet was effective: 1) the residents fill out the sheet themselves, which makes it easy to recognize potential issues and helps each resident become aware of disaster prevention actions from a practical perspective; and 2) by placing the sheet in a visible spot, such as on a refrigerator, it can be referred to regularly, and the information about specific evacuation locations can lead to frequent checks of the hazard map. It has been reported that actual disaster experiences and witnessing or hearing about disasters in other regions are the most significant factors influencing high disaster awareness (Hamamoto et al., 2017), and disaster prevention seminars are precisely what provide such opportunities. Therefore, to promote disaster prevention actions, it is first essential to encourage participation in disaster prevention seminars and then to implement measures to enhance the utilization of disaster-related tools (e.g., house rules sheet, hazard maps). However, there are obstacles to the use of hazard maps, which are the initial step in disaster prevention actions. Therefore, it is urgent to promote the use of hazard maps that are more user-friendly for residents. To achieve this goal, it is first necessary to include explicitly "checking the hazard map" within the house rules sheet to ensure a clear link between the house rules sheet and hazard map verification. Promoting the importance of both and integrating them into daily life is considered the most crucial step.

This study has several limitations. First, the number of cases is limited. Because the study involved a small sample of only 64 participants, there are limitations to the quantitative analysis, and it cannot be denied that the statistical power of individual data is low. However, the number of responses was comparable to that of the resident survey conducted by the local government concerning the heavy rainfall of July 2020. Second, the data are based only on those who agreed to participate in the questionnaire survey, so selection bias cannot be ruled out. Nevertheless, over 90% of the households visited agreed to participate in the survey. Third, the health status of the respondents was assessed using the questionnaire and was not based on concrete data, such as health checkup results. Fourth, to assess the level of disaster prevention awareness (phase classification), the questionnaire was simplified to reduce the burden on older residents by reducing the number of questions for each stage. Fifth, this study was cross-sectional and does not capture longitudinal changes over time; therefore, causal relationship cannot be examined. Additionally, because all surveys were self-reported, there is a possibility of information bias.

In conclusion, the findings of the present study indicated that the residents of the Yunohira area have relatively high disaster prevention awareness and strong attachment to the community. Despite repeatedly experiencing disasters since 2020 and continuing to feel the impacts on their physical and mental health, those who have experienced these disasters are striving for self-care to overcome these challenges. One possible reason why the population decline did not accelerate even after a series of severe disasters may be the residents' strong attachment to the community. In fact, community attachment showed a positive correlation with changes in health status from the time of the disaster to the present, independent of whether the individual had direct disaster experience. On the other hand, although disaster prevention awareness was high, obstacles remain to putting disaster prevention measures into practice. Therefore, specific measures are needed to promote the use of hazard maps as an initial step toward disaster prevention actions.

ACKNOWLEDGMENTS

This research was financially supported by a grant from the Fieldwork Support Program of the Regional Collaboration Platform Strengthening Program in Oita. We would like to express our deepest gratitude to the residents and ward chief of Yunohira district for their cooperation in the survey, and to Mr. Torao Akiyoshi of the Yufuin Promotion Bureau of Yufu city and Dr. Yoshihisa Tsurunari and Dr. Masayo Fukuda of Center for Education and Research of Disaster Risk Reduction and Redesign (CERD), Oita University, for their efforts in conducting the survey. We also wish to thank Tamami

Shiba, Eri Nogami, Moeno Tafuku, Yui Uemura, and Misato Imamura, fourth-year nursing students at the Faculty of Medicine Department of Nursing, Oita University, for their cooperation in the questionnaire survey, as well as Shotaro Iguchi, Ryoma Yoshimoto, Shuuto Ikeda, Miyu Fujimura, Suzuko Fukuda, and Haruhisa Yaoku, members of the student CERD. Finally, we wish to thank FORTE Science Communications (https://www.forte-science.co.jp) for the English language editing.

DISCLOSURES

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

Ren Fujinami contributed to the conception and design of the study, conducted the interviews, performed the quantitative data analysis, and drafted the original manuscript. Tetsuya Kakuma critically reviewed the manuscript, assisted with the preparation of figures and tables, and supervised the entire research process.

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